

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference ---	<b>FOR FURTHER ACTION</b> <span style="float: right;">See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)</span>	
International application No. PCT/EP99/03283	International filing date (day/month/year) 12/05/1999	Priority date (day/month/year) 14/05/1998
International Patent Classification (IPC) or national classification and IPC. G11B33/02		
Applicant THOMSON MULTIMEDIA		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I  Basis of the report
- II  Priority
- III  Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV  Lack of unity of invention
- V  Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI  Certain documents cited
- VII  Certain defects in the international application
- VIII  Certain observations on the international application

Date of submission of the demand 10/12/1999	Date of completion of this report 21.08.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Fichter, U Telephone No. +49 89 2399 2552



# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP99/03283

## I. Basis of the report

1. This report has been drawn on the basis of (substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.):

**Description, pages:**

1-7 as originally filed

**Claims, No.:**

1-10 as originally filed

### Drawings, sheets:

1/3-3/3 as originally filed

2. The amendments have resulted in the cancellation of:

- the description,      pages:
- the claims,      Nos.:
- the drawings,      sheets:

3.  This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

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International application No. PCT/EP99/03283

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)	Yes:	Claims 1-6
	No:	Claims 7-10
Inventive step (IS)	Yes:	Claims 1-6
	No:	Claims 7-10
Industrial applicability (IA)	Yes:	Claims 1-10
	No:	Claims

**2. Citations and explanations**

**see separate sheet**

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:

**see separate sheet**

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

**see separate sheet**

Reference is made to the following document:

D1: EP-A-0 163 549 (SONY CORP) 4 December 1985 (1985-12-04)

**Re Item V**

**Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

- 1 The comparison of subject-matter of present claim 1 with the disclosure of D1 reveals that the portable data player and/or recorder of claim 1 differs from the cassette tape recording and/or reproducing apparatus according to D1 in the fact that in a first range of angular opened positions a door which is rotatably attached around an axis with a casing can slide along said axis in one direction up to an axial position in which the door and the casing are disengaged from each other, and in a second range of angular opened positions the door is prevented against any translation movement along said axis by an abutment of a shoulder of the door against a shoulder of the casing.

It can not be derived from D1, to employ such a join mechanism for easily assembling or disassembling a door from the casing of a portable data player and/or recorder without the need of any tools.

Thus, it appears that the subject-matter of independent claim 1 is new and inventive. Claims 2 - 6 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

- 2 The portable data player and/or recorder of claims 7 - 9 are not new in the sense of Art. 33(2).  
Document D1 discloses (cf. fig. 5 and 6) a portable tape recording and/or reproducing apparatus comprising  
\*a casing (2) and a door (5) being rotatably attached around an axis (left and right pivot 20) to said casing,

- \*the door (5) and the casing being able to relatively take to each other of at least two ranges of angular positions in which the door (5) is open and of a closed position, said closed position being a position in which the door closes an opening of said casing,
- \*the door and the casing are fitted on with a shoulder (24) and the other with a rib (27), the rib being in abutment against the shoulder in one of the range of angular positions,
- \*the door and casing are fitted one with a tongue (28) and the other with a recess (24b, part of 24) whose dimensions are such that the tongue can enter the recess, the tongue being in a position in which it penetrates in the recess in one of the open positions,
- \*the tongue (28) is fitted on one of the rib (27) and shoulder (24) and the recess (24b) is fitted on the other one of the rib (27) and shoulder (24).

The support member 27 of D1 including the sliding block 28 which is attached to the lower end of the support member is considered to define the broad wording "rib" according to claim 7. Therefore, the rib (27, 28) is in abutment against (slidably fitted in) the shoulder (guide groove, 24) (see D1, page 5, 1st paragraph and figures).

3 Notwithstanding the objections raised in item VIII below, concerning clarity of the claim, the door of the portable data player and/or recorder according to claim 10 is not new in the sense of Art. 33(2).

Document D1 discloses (cf. fig. 5 and 6) a door (5) of a portable tape recording and/or reproducing apparatus comprising

- \*a door (5) having a main face and two first ribs (left and right support member 6) and a third rib (support member 27),
- \*the first two ribs (left and right support member 6) having holes (left and right pivot 20) denoting an axis and suitable to form brackets of the door, and
- \*the third rib (27) being substantially perpendicular to the main face of the door.

**Re Item VII**

**Certain defects in the international application**

1 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art

disclosed in the document D1 is not mentioned in the description, nor is this document identified therein.

2 Independent claim 1 is not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from the prior art (document D1) being placed in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).

**Re Item VIII**

**Certain observations on the international application**

1 The present set of claims comprises three independent claims 1, 7 and 10 each defining the invention partially by identical and partially by different features. Independent claims state the essential feature of the invention. Consequently, in the present case, it is not clear which features are in fact essential to the invention. Thus, the claims are not allowable since they are not clear and concise in the sense of Article 6 PCT.

Moreover, reference is made that the application lacks unity within the meaning of Rule 31.1 since the three independent claims do not have in common any feature defining contribution which each of the claimed inventions considered as a whole makes over the prior art. Hence, the three separate inventions

- (1) arrangement for disengagement of a door and a casing
- (2) attachment of a door and a casing by an abutment of a rib and a shoulder
- (3) door having two ribs with holes and a third rib perpendicular to the main face of the door

are not so linked as to form a single general inventive concept (Rule 13.1 PCT).

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EXAMINATION REPORT - SEPARATE SHEET**

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2 The geometrical description of the third rib in claim 10, lines 4 - 8 is confusing and not consistent. It is set out a third rib

- (1) being perpendicular to the main face of the door and
- (2) having a form such that it is not secant to planes containing said axis and
- (3) sensibly perpendicular to the main face of the door and
- (4) having a form such that it is secant to planes containing said axis and
- (5) forming an angle with the plane of the main face of the door which is less than about 90°.

These contradictions should have been deleted or at least sufficiently clarified.

## PCT/ISA/210 (first sheet) (July 1998)

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>PA980003</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/EP 99/03283</b>	International filing date (day/month/year) <b>12/05/1999</b>	(Earliest) Priority Date (day/month/year) <b>14/05/1998</b>
Applicant <b>THOMSON MULTIMEDIA</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

contained in the international application in written form.

filed together with the international application in computer readable form.

furnished subsequently to this Authority in written form.

furnished subsequently to this Authority in computer readable form.

the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2.  **Certain claims were found unsearchable** (See Box I).

3.  **Unity of Invention is lacking** (see Box II).

4. With regard to the **title**,

the text is approved as submitted by the applicant.

the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

the text is approved as submitted by the applicant.

the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

as suggested by the applicant.

because the applicant failed to suggest a figure.

because this figure better characterizes the invention.

1

None of the figures.

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 99/03283

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 G11B33/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 096, no. 008, 30 August 1996 (1996-08-30) -& JP 08 102178 A (KENWOOD CORP), 16 April 1996 (1996-04-16) abstract; figures 1A-2B ---	1-10
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 445 (P-1593), 16 August 1993 (1993-08-16) -& JP 05 094690 A (SONY CORP), 16 April 1993 (1993-04-16) abstract; figures 1-7 ---	1-10
A	US 4 661 865 A (IDA MITSURU ET AL) 28 April 1987 (1987-04-28) abstract; figures 1-8 column 4, line 1 - column 6, line 59 ---	1-10
-/-		

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

## ° Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

30 July 1999

Date of mailing of the international search report

06/08/1999

Name and mailing address of the ISA

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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 99/03283

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 163 549 A (SONY CORP) 4 December 1985 (1985-12-04) abstract; figures 1-6B page 2, line 32 - page 4, line 17 page 5, line 21 - page 7, column 11 ---	1-10
A	US 5 484 063 A (CUCCIO ALLEN ET AL) 16 January 1996 (1996-01-16) abstract; figures 1-6 column 2, line 35 - column 3, line 41 ---	1-10
A	PATENT ABSTRACTS OF JAPAN vol. 098, no. 001, 30 January 1998 (1998-01-30) -& JP 09 233382 A (SHARP CORP), 5 September 1997 (1997-09-05) abstract -----	1-10

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International Application No

PCT/EP 99/03283

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 08102178 A	16-04-1996	NONE	
JP 05094690 A	16-04-1993	NONE	
US 4661865 A	28-04-1987	AT 42160 T AU 560718 B AU 2874484 A BR 8402684 A CA 1223660 A EP 0128498 A	15-04-1989 16-04-1987 06-12-1984 07-05-1985 30-06-1987 19-12-1984
EP 0163549 A	04-12-1985	CA 1230416 A US 4614991 A	15-12-1987 30-09-1986
US 5484063 A	16-01-1996	NONE	
JP 09233382 A	05-09-1997	NONE	

0970141  
(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
19 April 2001 (19.04.2001)

PCT

(10) International Publication Number  
WO 01/27514 A1

(51) International Patent Classification<sup>7</sup>: F16L 7/02 [US/US]; 3815 Darbyshire Drive, Hilliard, OH 43026 (US).

(21) International Application Number: PCT/US00/28303

(74) Agent: CROWLEY, Richard, P.; 901 Main Street, P.O. Box 901, Osterville, MA 02655-0901 (US).

(22) International Filing Date: 13 October 2000 (13.10.2000)

(25) Filing Language: English

(81) Designated States (national): AE, AU, BR, CA, CN, CZ, DZ, ID, IN, JP, MX, NO, TT, US.

(26) Publication Language: English

(84) Designated States (regional): Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

(30) Priority Data:  
60/159,282 13 October 1999 (13.10.1999) US

(71) Applicant (for all designated States except US): CHART INC. [US/US]; Suite 150, 5885 Landerbrook Drive, Mayfield Heights, OH 44124 (US).

Published:

— With international search report.

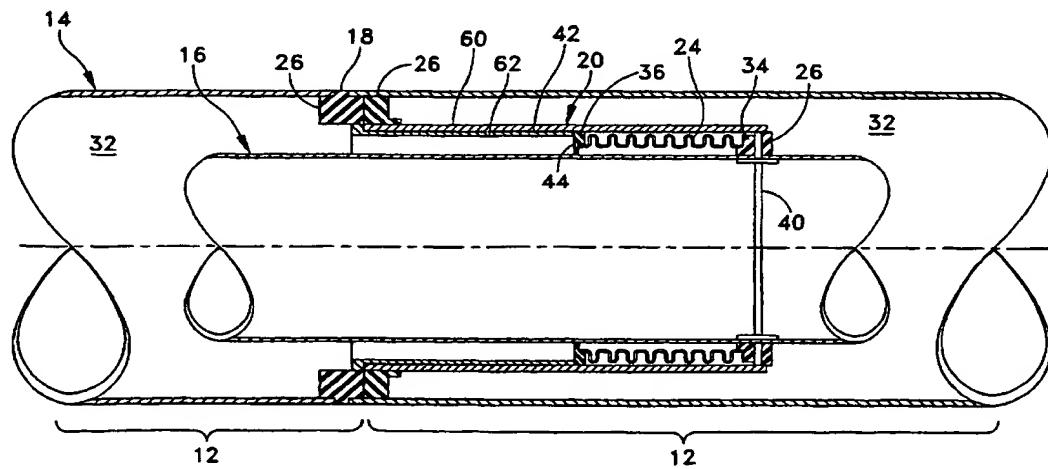
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(72) Inventor; and

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(54) Title: VACUUM-JACKETED BAYONET PIPE SPOOL AND PIPE SPOOL SYSTEM FOR CRYOGENIC FLUID



WO 01/27514 A1

(57) Abstract: A vacuum-jacketed bayonet pipe spool system for cryogenic fluid. The pipe spool comprises a male bayonet (20) to fit within a female bayonet (22) of an opposing pipe and an expansion-contraction bellows (24) about the outer end of the male bayonet (20) for stress-free movement.

**VACUUM-JACKETED BAYONET PIPE SPOOL AND  
PIPE SPOOL SYSTEM FOR CRYOGENIC FLUID**  
**Reference to Prior Application**

This application incorporates by reference in its 5 entirety and claims the benefit of the filing date of U.S. Provisional Patent Application Serial No. 60/159,282, filed October 13, 1999.

**Background of the Invention**

Cryogenic fluid piping systems, for example, for 10 transport of liquified natural gas (LNG) or other cryogenic fluids, typically, employ vacuum-jacketed male and female bayonet connectors therein.

U.S. Patent No. 3,885,595, issued May 27, 1975, shows a conduit for cryogenic fluid transport. Each conduit section 15 has a male and a female end such that the conduit section can be laid end to end with similar conduit sections to form a continuous conduit. Each conduit section has an inner and an outer pipe. The space between the inner and outer pipe is filled with insulation. Both the male end and female end are 20 frusto-conical in shape and telescoped together in use. A thermal motion compensator, i.e., a metal bellows, is secured about the female end of the inner pipe. In the assembled state, the outer pipes of adjacent conduit sections are welded to each other. In the operating state, pressure from the 25 cryogenic fluid flowing inside the inner pipe acts upon the outside of the thermal motion compensator and is contained from the environment by the outer pipe welds. A liquid seal is provided between the male and female ends of the inner pipe.

30 German Patent No. 315487, issued July 25, 1931, shows an expansion-compensating conduit connection. A male end of a first conduit section is inserted into a female end of a second conduit section. An expansion compensator is located on the male end of the first conduit section.

U.S. Patent No. 4,515,397, issued May 7, 1985, shows a vacuum-insulated conduit. The conduit comprises an inside pipe and an outside pipe. A plate having a radially solid portion connects the end of the outer pipe to one end of a 5 bellows, which is located around a portion of the inner pipe that extends beyond the end of the outer pipe. The opposite end of the bellows is connected to the outer circumference of the inner pipe. The space between the inside and outside pipe is evacuated to form a vacuum. Other U.S. patents relative to 10 cryogenic systems include U.S. Patent No. 4,011,732, issued March 15, 1977, and U.S. Patent No. 4,107,946, issued August 22, 1978.

It is desirable to provide a new, improved, vacuum-jacketed, male-female bayonet connector particularly useful in 15 cryogenic fluid piping systems, such as LNG systems, and which connectors allow for stress-free thermal expansion and contraction and eliminate or reduce the need for expansion loops in the system.

#### Summary of the Invention

20 The invention relates to a male-female bayonet or pipe spool connector with a male bayonet with an expansion bellows and a cryogenic fluid piping system employing the connector.

The invention comprises and is directed to a bellows and male bayonet connection for connecting vacuum-jacketed pipe 25 spool sections to one another. The connection allows stress-free thermal expansion and contraction of the inner pipe within each spool, thus, eliminating or reducing the need for expansion loops. Within an outer pipe is an inner pipe. The inner pipe carries cryogenic fluid at a certain pressure and 30 temperature. The space between the outer pipe and the inner pipe is evacuated to form an insulating vacuum jacket around the inner pipe. The male end of the spool comprises a male bayonet portion and expansion peripheral bellows secured about the exterior of the male bayonet at the open end. The male 35 bayonet portion is attached to a first annular seal between

the male bayonet portion and the outer pipe at one end and to the bellows at the other open end. The opposing end of the bellows is attached to a male end of the inner pipe. The spaces between the male bayonet portion and the inner pipe, 5 between the bellows and the inner pipe and between the outer pipe and the inner pipe, communicate with one another and are at the same vacuum pressure.

The female end of the spool comprises a female bayonet portion that is attached to a female end of the inner pipe. 10 The opposing end of the female bayonet portion is attached to a second annular seal between the female bayonet portion and the outer pipe. The spaces between the female bayonet portion and the outer pipe, and between the outer pipe and the inner pipe, communicate with one another and are at the same vacuum 15 pressure. The male and female spool ends connect together by a means to connect, such as a bolted flange connection, a clamped connection, or a welded connection. When a rise or fall in temperature causes the inner pipe to lengthen or shorten, the male end of the inner pipe moves and extends or 20 compresses the surrounding secured bellows. The female end of the inner pipe is fixed to and does not move in relation to the female bayonet portion. The bayonet connection results in a nearly uninterrupted, smooth interior wall of the inner pipe that is conductive to smooth, non-turbulent, cryogenic fluid 25 flow.

The invention comprises a cryogenic fluid piping system with a plurality of two or more coupled first and second pipe spools, the first pipe spool having an outer pipe and a concentric inner pipe to carry cryogenic fluid, the outer pipe 30 and inner pipe forming a vacuum-insulated connection, and a male bayonet at the one end of the first pipe spool having an external, male sealing surface, and having a first open end and other end, and an expansion-contraction peripheral bellows longitudinally about the external surface of the male bayonet 35 adjacent the first open end, and a means to secure the one end

of the bellows about the external surface to the first open end of the male bayonet.

The invention also comprises a second pipe spool having an outer pipe and a concentric inner pipe to couple with the 5 first pipe spool to carry cryogenic fluid in the coupled inner pipe and to form a coupled, vacuum-insulated connection, the female bayonet having an internal, female sealing surface and a first open end and other end arranged and constructed to form a telescoped, zero tolerance, cryogenic vapor seal 10 between the external surface of the male bayonet and the internal surface of the female bayonet for the stress movement of the bellows in the coupled use position; and a means to connect the opposing ends of the outer pipe of the first pipe spool and the second pipe spool.

15 The invention will be described for the purpose of illustration only in connection with certain illustrated embodiments; however, it is recognized that various changes, modifications, additions, and improvements may be made by those persons skilled in the art of the invention, as 20 described and disclosed, without departing from the spirit and scope of the invention.

#### Brief Description of the Drawings

Figs. 1A, B, and C are schematic sectional views of three types of assembled bayonet connectors of the invention;

25 Fig. 2 is an exploded, sectional assembly view of one embodiment of the connector of Fig. 1A;

Fig. 3 is an enlarged, detailed sectional view of the assembled connector of Fig. 1A; and

Fig. 4 is a schematic sectional view of a pipe spool of 30 the invention.

#### Description of the Embodiments

Fig. 1 shows three sectional views, A, B, and C, of coupled, cryogenic, pipe spool connectors together to form a coupled, pipe spool system 10 comprised of mating ends of 35 separate pipe spools 12. Fig. 1 illustrates various means to

connect the ends of engaged, male-female pipe spools 12 to include, but not be limited to: Fig. 1A, a welded bayonet assembly 26 wherein the pipe spools 12 have mating standoff ring closures at each open end with a butt weld construction.

5 Fig. 1B illustrates a flanged bayonet assembly 28 of a standoff ring closure at each pipe spool 12 and with a bolt or thread flange connection 28. Fig. 1C illustrates a clamped bayonet assembly 30 for the coupled pipe spools 12 with a standoff ring closure with a ring clamp as the connector.

10 With reference to Figs. 2 and 3, there are shown two aligned, opposing, end pipe spools 12 with an outer pipe 14 and an inner pipe 16, with a male bayonet 20 and a female bayonet 22, with an end of defined depth 46, and with an internal sealing surface 60. The male bayonet 20 includes a 15 peripheral, metal, expansion-contraction bellows 24 secured at the one, outer step-down end of the open, male, inner pipe section 40 with flange 34. A concentric pipe 42, which forms the external, male, sealing-mating surface 62 of the male bayonet 20, with an inner flange 44 secured along a selected 20 length of the male bayonet 20 and upstream of the bellows 24. The inner end of the bellows 24 is secured to the inner bellows flange 36 of the step-up concentric pipe 42.

Figs. 2 and 3 illustrate the welded bayonet connection means with butt weldable flanges at the open end of the female 25 bayonet 22 and at the inner end of the concentric pipe 42, with a butt flange 44 at the end of the pipe. The inner pipe 16 and outer pipe 14 in the coupled position form a jacket vacuum 32 between the coupled pipe spools 12. The bellows 24 forms a bellows space forward of the male 30 bayonet, external mating surface 62. Fig. 3 shows the coupled pipe spools 12 in an overlapping, butt weld connection 26 in the use position (see Fig. 1A also). At all times, an overlapping connection is required to assure a zero tolerance fit between sealing surfaces 60 and 62.

Fig. 4 is a schematic illustrative view of a single pipe spool 12 of the invention and is used in connection with the coupled, aligned pipe spools 12 to form the cryogenic, coupled pipe spool system 10. The pipe spool 12 includes a pump-out 5 valve or port 48 to achieve vacuum insulation after coupling, a thermocouple gauge tube 50 to read the vacuum level of each pipe spool 12, and an isolation valve 52. The pipe spool 12 includes, preferably, insulation 54 about the inner pipe 16. Low conductive pipe spacers 56 are positioned longitudinally 10 along the vacuum space 32. The pipe spool 12 includes an external, expansion-contraction metal bellows 58 in the outer pipe 14.

With further reference to the drawings, a vacuum-jacketed inner pipe 16 with a male bayonet 20 is shown that 15 incorporates a bellows 24 in the nose of the bayonet, of pipe sizes ranging from about 1/2 inch to 48 inches in diameter plus. This design allows thermal contraction or expansion of the inner pipe 16 based on the cryogenic fluid temperature, without imposing stresses on the piping system, and eliminates 20 the need to incorporate large expansion loops in long runs of cryogenic fluid piping.

With a bellows 24 in the nose of the male bayonet 20, it will be under external pressure when the internal pipe 16 is pressurized, and the bellows 24 can operate at a higher 25 pressure than it could if was under internal pressure when the bellows 24 is on the female bayonet 22. The bellows 24 is captured between the outside of the inner pipe 16 and the inside of the outer pipe 14 with the female bayonet 22, which will guide the bellows 24 and eliminate the possibility of 30 squirm or undesired movement. Each vacuum-insulated section of pipe spool 12 will be supplied with a bellows 24 in the male bayonet 20 and a female bayonet 22 at the opposite end. When connected in the field with other vacuum-insulated pipe 35 spools 12, the thermal stress will be no greater than that contained within each pipe spool 12. This will eliminate the

requirement for a finite element analysis on the piping system. Incorporating the bellows 24 in the male bayonet 20, with external pressure on the bellows 24 is important, since it will compress the bellows 24 when the inner pipe 16 is 5 cooled with cryogenic fluid, which causes the inner pipe 16 to contract. The location of the bellows 24 on the outside surface of the male bayonet 20 will maintain the inner pipe 16 smooth, which reduces the pressure or friction losses in the pipe when transferring fluids. This design eliminates the 10 requirement for expansion loops, further reducing the fluid flow friction and the amount of pipe and fitting required. Incorporating the bellows 24 in the male bayonet 20 allows for easy cleaning of the inner pipe 16 and bellows 24 before field assembly. Incorporating the bellows 24 in the male bayonet 20 15 eliminates collecting dirt or other particles in the convolutions of the bellows 24 that could be hazardous or cause bellows 24 damage during thermal cycling.

While the male-female pipe spool 12 design is shown in straight line form, it is recognized, and in fact preferred, 20 that the male-female pipe spool 12 be in a slight frusto-conical form, with tapered contacting surfaces of, for example, about 0 to 15 degrees.

Each fabricated pipe spool 12 will have a male bayonet 20 with bellows 24 at one end, and the other end can have a 25 female bayonet 22; male bayonet 20 without bellows 24; standoff ring closure with a fillet, groove, or butt weld connection 26; or standoff ring closure with flange connection 28. The pipe spool 12 end connection opposite the male bayonet 20 with the bellows 24 can have a bend in the end 30 just prior to the fixed male or female bayonet 20 or 22, without adding additional flexibility or bellows 24 to the pipe.

Pipe spool assemblies can run long distances in one direction and will permit you to change direction up to

90 degrees in another direction, without concern for thermal stresses building up in the piping.

The male and female bayonets 20 and 22 are designed to mate with a high tolerance fit when connected. The male and 5 female bayonets 20 and 22 may also be tapered by the same angle of taper and connected together with a near zero tolerance fit when connected.

The shop-fabricated pipe spools 12 will be delivered to the field with a permanent static vacuum and connected by 10 flanged joints 28, clamped joints 30, or welded joints 26. Elastomeric "O-rings" will be required for the flanged and clamped joints 28 and 30 to achieve the pressure seal for the cryogenic fluid. The welded joint 26 will not require "O-rings"; welding will seal the piping.

15 The inner pipe 16 material should be stainless steel or another compatible material with cryogenic fluid, and the outer pipe 14 will be designed for the atmospheric environment where it will be installed. This material can be stainless steel or carbon steel with a proper outer coating to eliminate 20 or reduce corrosion or aluminum.

This piping design can be used underground, aboveground, and underwater for the transport of cryogenic fluids. The outer pipe 14 design can be modified to meet the pressure and environmental requirements of being placed underground or 25 underwater.

The pipe spool system may be used in both underground vacuum-insulated pipe (VIP) and underwater vacuum-insulated pipe (VIP) for annular space relief device manifolding. In an underground VIP system, the pump-out valve relief device can 30 be manifolded to collect all vent gases in a vent header and vent all flammable or hazardous gases in a safe area away from the pipe spool relief device. In an underwater VIP system, the vent piping outlet is above the water line to prevent water from entering into the annular space during venting or

relieving of gas from the annular space between the inner and outer pipe.

When the pipe is placed underground, a vertically-oriented open pipe will be located above each pump-out valve 48 location and will be capped above grade to provide access for evacuation and monitoring. Vacuum-insulated piping installed underwater will be maintained in position with ballast anchors around the pipe to secure the pipe to the seabed. Pump out ports 48 will be sealed with a cover of seawater-compatible material and act as a rupture disc, if the pump-out valve 48 relief device is activated. The relief device will also incorporate a check valve that will close when the relieving is stopped, to prevent seawater from entering the annular space. The underwater piping may also be provided with a vertically-oriented tube centered over the pump-out valve 48, which is seal-welded to the pipe and extends above the water at high tide, and that is capped to prevent seawater from entering into the vertical tube.

The male bayonet 20 is provided with a flange that is welded to the outer pipe 14. The outer end of the male bayonet 20 has a flange which is welded to the male bayonet 20 and has a clearance fit of approximately 0.062 inches around the outside of the inner pipe 16. One end of the bellows 24 is welded to an end flange which is also welded to the inner pipe 16. The end flange is larger in diameter than the bellows 24 to protect the bellows 24 from damage during handling and installation into the female bayonet 22. The outside diameter of the end flange is rounded or tapered to help guide and align the male bayonet 20 into the female bayonet 22.

The female bayonet 22 length is extended to allow space for the bellows 24 that is attached to the end of the male bayonet 20. This length will act as a guide to the bellows 24 and keep the bellows 24 from squirming, due to thermal expansion and contraction of the inner pipe 16.

Each factory-fabricated pipe spool having a male bayonet 20 at one end and a female bayonet 22 at the other opposite end will be insulated with multilayer insulation 54 wrapped around the inner pipe 16. A vacuum in the annular 5 space will be achieved using the pump-out valve 48 welded to the outer pipe 14. Provisions will be provided to read the vacuum level of each pipe spool 12 by a thermocouple gauge tube 50 that can be isolated from the vacuum space 32 by a valve 52. The inner pipe 16 is supported along the length by 10 low thermal conductive pipe spacers 56. These pipe spacers 56 are attached to the inner pipe 16 and extended to the inside diameter of the outer pipe 14. The pipe spacers 56 slide or roll along the outer pipe 14.

An outer pipe bellows 58, typically, needs to be added to 15 one of the pipe spools 12 of the coupled system between two fixed supports. This outer pipe bellows 58 allows the outer pipe 14 to shrink and expand under environmental temperature changes, i.e., from summer to winter conditions and daytime to nighttime conditions. The outer pipe bellows 58 will also 20 allow the outer pipe 14 to shrink upon the loss of vacuum of any pipe spool 12 between the fixed support points. Pipe spacers 56, located on either side of the outer pipe bellows 58, maintain axial alignment of the bellows 58. Standard pipe supports allow the outer pipe 14 to move 25 axially.

Large bore, vacuum-insulated piping running long distances aboveground could be equipped with a monorail system integrated to the outer pipe 14. Service carts, manned access carts, and unmanned diagnostic carts would run on the monorail 30 system for service and maintenance of these pipes. These carts are powered using natural gas, internal combustion engines. The engine operates a generator that powers electric driver motors, which are attached to wheels mounted to the monorail. The primary purpose of the access carts and service 35 carts is to monitor the vacuum level in each pipe spool 12,

repair the leak, and re-evacuate the vacuum space 32. This is accomplished by using an infrared temperature sensor focused on the outer pipe 14 and recording the temperature of each pipe spool 12, as the manned or unmanned access carts are 5 driven by the pipe spool 12. A large variation in temperature from one pipe spool 12 to another will indicate a leak in the annular space. All necessary equipment to repair the leak will be located the service cart. This equipment consists of: 10 spare parts; methane detector; vacuum pump; helium mass spectrometer leak detection equipment; welding equipment; an electric generator; LNG fuel tanks; communication and instrumentation equipment; a video camera; and a fold-up access platform attached to the service and access cart.

Each pipe spool 12 will be numbered with numbers that are 15 visible to the video camera and that can be transmitted via closed circuit television to a base office, to give the location of the unmanned or manned access carts. The outer pipe 14 temperature will also be transmitted to the base office for evaluation.

20 Access and service carts riding on the monorail eliminate the requirement for a service road to run parallel with the pipe, thereby further reducing the installed cost of the pipe and reducing the environmental impact in remote areas.

The invention provides for and permits transport of LNG 25 and other cryogenic fluids long distances, with minimum refrigeration losses and low thermal stresses.

Claims

What is claimed is:

**Claim 1.** A cryogenic fluid piping system which comprises  
2 a plurality of two or more coupled first and second pipe  
spools:

4           a) the first pipe spool having an outer pipe and  
a concentric inner pipe to carry cryogenic fluid, the outer  
6 pipe and inner pipe forming a vacuum-insulated connection, and  
a male bayonet at the one end of the first pipe spool having  
8 an external male sealing surface and having a first open end  
and other end, and an expansion-contraction peripheral bellows  
10 longitudinally about the external surface of the male bayonet  
adjacent the first open end, and a means to secure the one end  
12 of the bellows about the external surface to the first open  
end of the male bayonet;

14           b) the second pipe spool having an outer pipe and  
a concentric inner pipe to couple with the first pipe spool to  
16 carry cryogenic fluid in the coupled inner pipe and to form a  
coupled, vacuum-insulated connection, the female bayonet  
18 having an internal, female sealing surface and a first open  
end and other end arranged and constructed to form a  
20 telescoped, zero tolerance, cryogenic vapor seal between the  
external surface of the male bayonet and the internal surface  
22 of the female bayonet for the stress movement of the bellows  
in the coupled use position; and

24           c) a means to connect the opposing ends of the  
outer pipe of the first pipe spool and the second pipe spool.

**Claim 2.** The system of claim 1 which comprises a  
2 plurality of coupled, aligned pipe spools without expansion  
loops.

**Claim 3.** The system of claim 1 wherein the first pipe  
2 spool, or second pipe spool, or both comprise a male bayonet  
and bellows at one end and a female bayonet at the other  
4 opposite end.

**Claim 4.** The system of claim 1 wherein the external-  
2 internal mating surfaces of the male bayonet and the female  
bayonet are frusto-conical in shape.

**Claim 5.** The system of claim 1 wherein the means to  
2 connect the first and second outer pipes is selected from the  
group consisting of: a butt weld; a flange; a clamp; and  
4 combinations thereof.

**Claim 6.** The system of claim 1 which includes an  
2 expansion-contraction external bellows in the first or second  
outer pipes, or both.

**Claim 7.** The system of claim 6 wherein the bellows is  
2 between the male bayonet and female bayonet.

**Claim 8.** The system of claim 1 wherein the means to  
2 secure the first pipe spool comprises an outer flange at the  
one open end of the male bayonet and a second flange  
4 longitudinally spaced apart from the first flange to form a  
bellows space for the bellows, the one and other end of the  
6 bellows secured to the flanges.

**Claim 9.** The system of claim 8 wherein the means to  
2 secure includes a step-up concentric section downstream of the  
bellows and about the open end to form the external sealing  
4 surface of the male bayonet and spaced apart from the one open  
end.

**Claim 10.** The system of claim 1 wherein the first or  
2 second pipe spool include a pump-out valve and a means to  
monitor the vacuum between the outer and inner pipes.

**Claim 11.** A pipe spool having a one and other end and  
2 adapted for use with other pipe spools in a coupled, male-  
female bayonet relationship to form a cryogenic fluid pipe  
4 system, which pipe spool comprises:

- a) an outer pipe;
- 6 b) an inner concentric pipe to form a vacuum-  
insulated jacket with the outer pipe and the inner pipe to  
8 carry cryogenic fluid;
- c) a male bayonet at the end of the pipe spool;

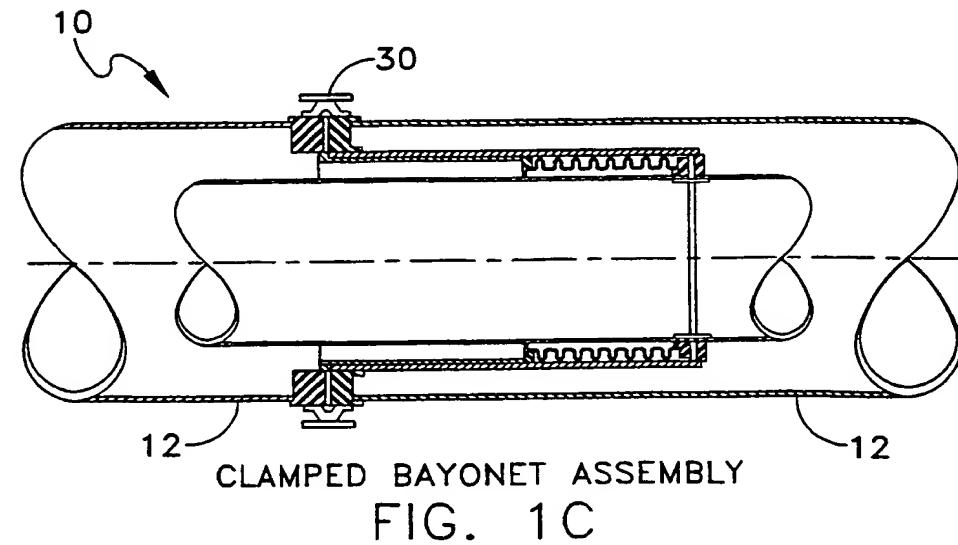
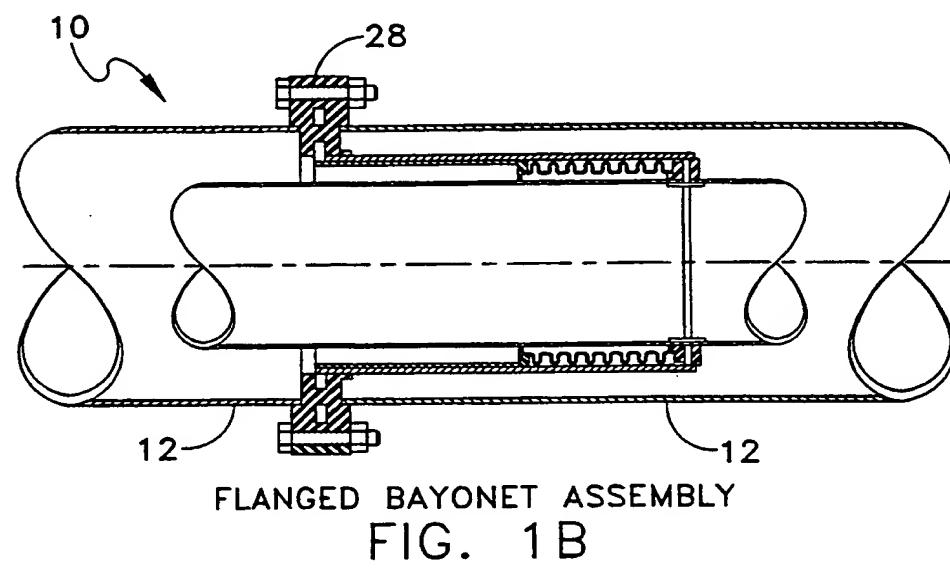
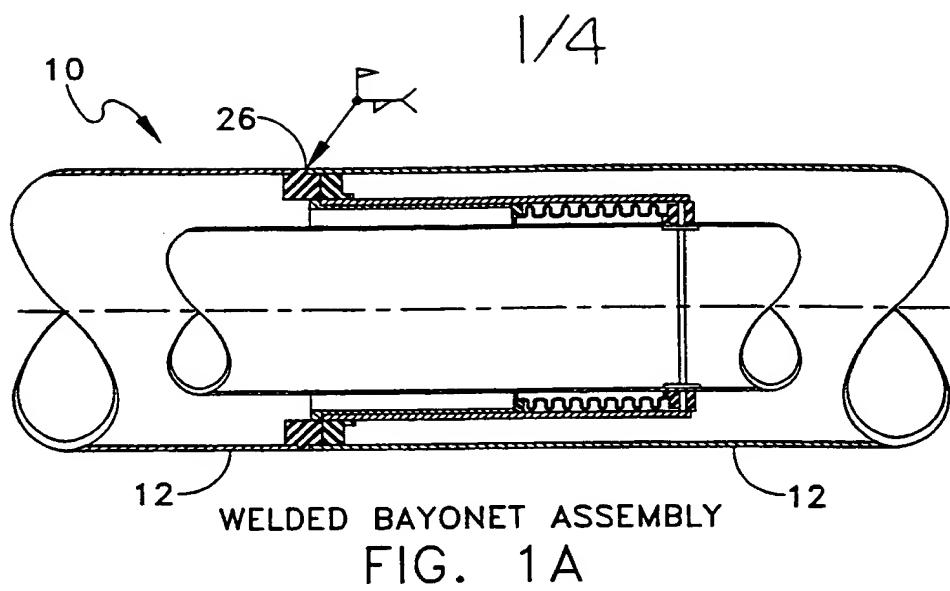
10                   d) a female bayonet at the other opposing end of  
the pipe spool, the male bayonet and female bayonets arranged  
12 and constructed to couple in a zero tolerance manner with the  
opposing male bayonet or female bayonet of another pipe spool;  
14                   e) an expansion-contraction bellows about a  
peripheral surface of the male bayonet, extending from a one  
16 open end of the male bayonet;  
18                   f) a means to secure the bellows about the male  
bayonet; and  
20                   g) a means at the one and other end of the outer  
pipe to connect the ends of the other pipe to adjoining,  
aligned outer pipes of the outer pipe spools.

Claim 12. The pipe spool of claim 11 wherein the male  
2 bayonet and female bayonet are frusto-conical in shape.

Claim 13. The pipe spool of claim 11 which includes an  
2 external expansion-contraction bellows in the outer pipe.

Claim 14. The pipe spool of claim 11 which includes a  
2 step-up concentric section about the male bayonet at the one  
end to form the external, male sealing surface adjacent the  
4 internal, female sealing surface, and the means to secure  
includes a flange at the one open end of the male bayonet to  
6 secure one end of the bellows and the other end of the bellows  
to an inner end of the concentric section.

Claim 15. A coupled cryogenic fluid piping system which  
2 comprises a plurality of aligned, coupled pipe spools of  
claim 11 having a vacuum insulation between the inner and  
4 outer pipes.



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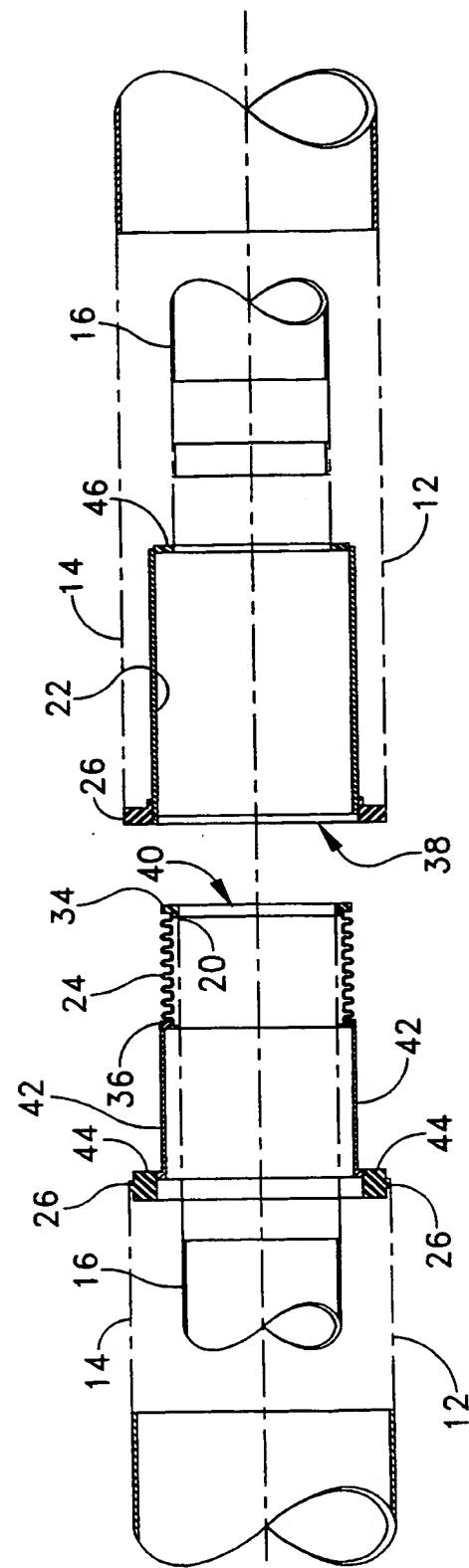


FIG. 2

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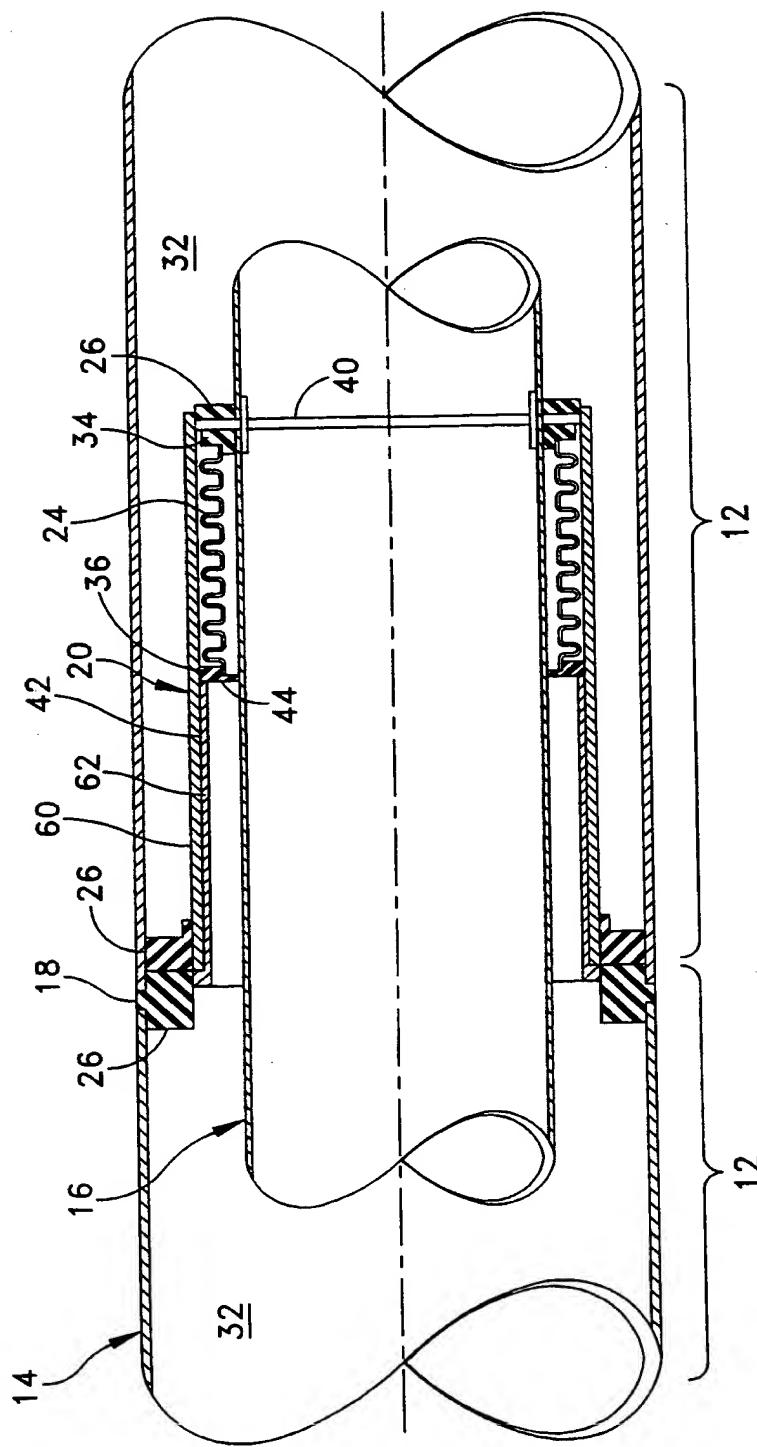


FIG. 3

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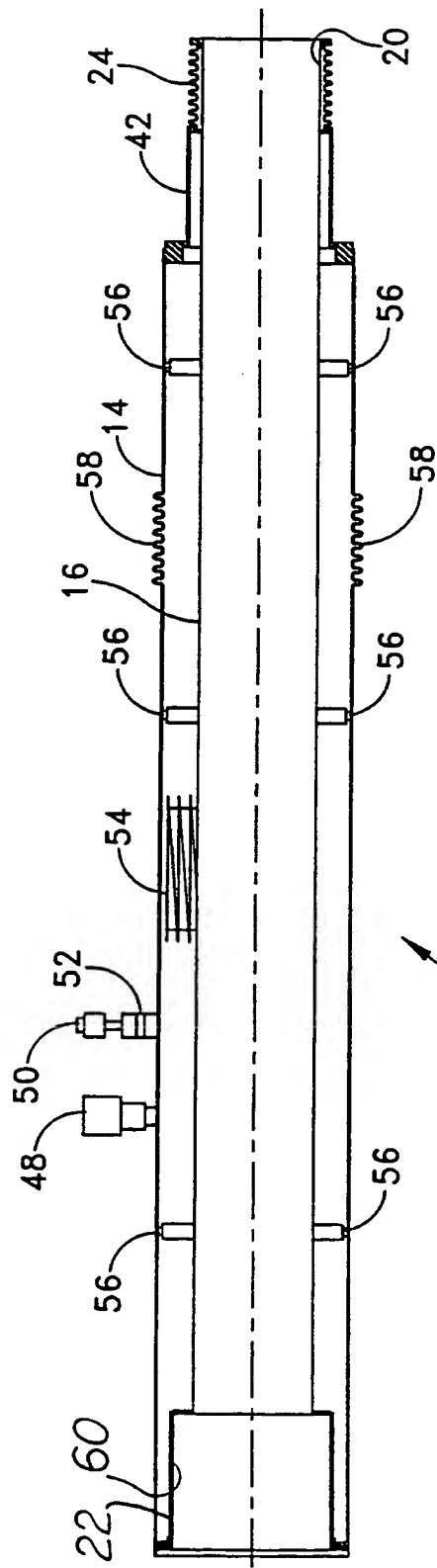


FIG. 4

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US00/28303

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : F16L 7/02

US CL : 285/123.15, 123.17, 47, 226, 904, 906

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 285/123.15, 123.17, 47, 226, 904, 906; 62/50.7

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US3,068,026A (McKAMEY) 11 December 1962 (11/12/62)	1-15
A	US4,011,732A (DOHERTY ET AL) 15 March 1977 (15/3/77)	1-15

 Further documents are listed in the continuation of Box C.  See patent family annex.

"	Special categories of cited documents.	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
05 DECEMBER 2000	25 JAN 2001

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